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Payload Operations Report
Deep Impact Observations

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Modified by: K.R. Wirth

Created by: K.R. Wirth

Approved by: D. Koschny

CHANGE RECORD SHEET

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23 Sep 2005	D	-	All	Initial release.	
24 Oct 2005	1	-	All	Incorporated comments by D. Koschny, V. Dhiri and R. Solaz. Completed resources analysis (section 5).	
06 Dec 2005	1	1	Table 2, 3.3, 4.2, 4.3, 5, Table 4	Incorporated inputs by ALICE.	

Issue to issue revisions are indicated by a vertical bar at the outside border.

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1. General Remarks

1.1 Summary

All of the payload activities during the Deep Impact Observations scenario shall be summarised. Firstly, the scientific results achieved by each experiment team are summarised with a view of the initial high level requests listed in the MSP. PI team reports shall be referenced. Secondly, this is designed to be complementary to the daily pass reports being provided by RMOC by reporting the problems and planning feedback that do not show up as OOL / events or Anomaly Reports. Subsequent investigations are tracked in RD3 and RD4.

1.2 Deep Impact Observations Scenario Details

The following table gives the DI Observations dates and times.

Table 1: DI Observations dates and times.

Start	End	Comments
27-Jun-2005 (DOY178)	28-Jun-2005 (DOY179)	ALICE calibration star observation.
28-Jun-2005 (DOY179)	15-Jul-2005 (DOY196)	9P/Tempel 1 observation. OSIRIS, ALICE and MIRO operated continuously. VIRTIS operated for several hours around the impact on 04-Jul-2005 (DOY185). Maintenance activities were carried out for COSIMA, ROSINA and ALICE. SREM was kept alive in background radiation monitoring as normal for the active cruise phase.

1.3 Applicable Documents

AD1 MSP Deep Impact Observations, RO-EST-PL-3311, Issue 2.3, 17 Jun 2005.

AD2 Rosetta Timeline Details Deep Impact Observations, RO-EST-TN-3315, Issue 1.3, 17 Jun 2005.

AD3 CSPL Deep Impact Observations, RO-EST-LI-3314, Issue 1.1, 27 Apr 2005.

AD4 EVF_MAN_DEEP_IMPACT_OBSERVATION.EVF

AD5 Rosetta Mission Operations Report (WOR #45), RO-ESC-RP-5018, Issue 1.0, Period 24 Jun - 15 Jul 2005, Deep Impact Observation Campaign.

1.4 Reference Documents

RD1 Rosetta Project Glossary, RO-EST-LI-5012, http://www.rssd.esa.int/index.php?project=ROSETTA&page=glossary.

RD2 Rosetta Payload Boresight Alignment Details, RO-EST-TN-3305, Issue 1.5, 5 Apr 2005.

RD3 Rosetta Payload Open Issues Report, RO-EST-RP-3346, Issue 1.0, 21 Oct 2005.

RD4 PL OOL Events Investigation, RO-EST-LI-3326, Issue 1.1, 27 Sep 2005.

RD5 Anomaly Report ROS-SC-93: OSIRIS Commanding Problem during Deep Impact campaign.

RD6 Anomaly Report ROS-SC-94: Slow SSMM Link Event (EID 3452) Received from CAM A.

RD7 Anomaly Report ROS-SC-95: ROSINA DFMS Switch-off Fails.

RD8 Anomaly Report ROS-SC-96: MIRO Suspends Telemetry Generation and TC Processing for about 20 hours.

RD9 Anomaly Report ROS-SC-97: Not Possible to Downlink WAVELET Compressed NAVCAM Images.

RD10 Anomaly Report ROS-522: Incorrect Window Settings for NAVCAM Images of Comet Tempel-1.

RD11 Anomaly Report ROS-523: Problems with TM Decoding at New Norcia After Transponder Sustained Lock.

RD12 Minutes of Rosetta MOC-SOC Interface Meeting (RRIM) #16, 3 Aug 2005, OPS-OPR230PF.

RD13 Results of the OSIRIS observations of Deep Impact target comet 9P/Tempel1, RO-RIS-MPAE-RP-158, Issue 1.0, 15 Sep 2005.

RD14 OSIRIS Deep Impact Observations Science Plan, RO-RIS-MPAE-PL-007, Issue 2.0, 18 May 2005.

RD15 Observations of 9P/Tempel 1 by Rosetta-ALICE UV Spectrograph, Presentation at SWT #19, 2 Sep 2005.

RD16 Deep Impact Observations with MIRO, Presentation at SWT #19, 2 Sep 2005.

2. Results of Observations

Table 2 compares the high level requests of observations that have been run in the DI Observations scenario (Table 4 in the MSP AD1) with the reported results. References to the PI team reports are also given.

Table 2: High level requests vs. results of observations.

OBS	Title	Objectives	Results	Ref.
SR01	Monitoring	• Accurate photometry of the unresolved nucleus (no atmosphere in between) with complete time coverage. • UV coverage 250…300 nm (unaccessible from Earth). • Imaging of the coma from a different geometry than from Earth.	• The accurate photometry has been achieved completely. We got time resolution better than a minute around the impact and could draw conclusions about the evolution of the "impact cloud" during the first hour. The long term monitoring allowed determination of the composition and evolution of the impact cloud. Particularly our results about the water production and the dust/ice ratio are widely cited. • The UV coverage allowed imaging of the OH emission at 308 nm which is very difficult to do from the ground due to atmospheric extinction. This helped us to get the best estimate of the water production by the impact published so far. • We see the coma of the comet out to at least 150000 km from the nucleus. The effect of the impact can be seen in the images for approximately a week. This allows stereo reconstruction of the coma and perhaps the impact cloud by combination with earth-based images. However, this is a long-term endeavour and there are no results yet. In summary, all our objectives have been met. (Reference: E-mail by Michael Küppers of 14 Sep 2005.)	RD13, RD14

OBS	Title	Objectives	Results	Ref.
VR01	Impact spectral mapping	Coma and ejecta composition and temporal evolution.	The outburst due to the impact although relevant was not energetic enough to reach the minimum sensitivity level required. (Reference: E-mail by Fabrizio Capaccioni of 8 Jul 2005.)	–
AL01	5-point jailbar histograms	• Establish the baseline UV emission levels and evolutionary trends prior to the impact as a function of time. • Measure the change and behaviour of the water production rate as a result of the impact as a function of time. • Obtain the evolution of the rate at which material is expelled (spatial measurement) due to the impact as a function of time. • Measure the quantity and time evolution of trace species, particularly including extreme volatiles (like sulphur, carbon monoxide), some of which have extremely short lifetimes (~ 10 minutes). • Measure velocity of H atoms as a function of time after the impact. Look for deviations from a spherical distribution.	We were able to establish the baseline pre-impact spectrum and compare it with the near- and long-term post-impact spectra. Alice detected the comet in all spectra. Strong atomic lines of neutral H and O were detected throughout the observation period. Two weak lines of neutral C may have been detected on some dates. Except for possible enhancement in C emission, no changes were detected in the comet's UV spectrum by Alice as a result of the impact. No evidence of Ar, S, N, or CO was detected. Water production rates are still to be determined. (Reference: E-mail by Joel Parker of 31 Oct 2005.)	RD15
AL02	Impact staring histograms			
AL03	Dark histograms	Dark reference.	The darks were obtained as expected. (Reference: E-mail by Joel Parker of 31 Oct 2005.)	

OBS	Title	Objectives	Results	Ref.
AL04	Calibration star	In-flight stellar calibration observations will be made during the mission prior to the start of the encounter sequences of science targets (reference: section 3.1.7 of the ALICE User Manual).	Spectra of the calibration star were obtained and are of good quality to be used for calibration of the Deep Impact spectra and the instrument sensitivity. The data were also used to look for any flux variations due to pointing/jitter; initial results do not show any evidence of significant fluctuations in the stellar count rate. (Reference: E-mail by Joel Parker of 31 Oct 2005.)	
AL05	Memory patch	Memory patching of EEPROM pages 0-2 with the same code that was uploaded to page 3 in Sep 2004 in order to correct the time synchronisation problem. Final step in closing the Anomaly Report. Patch should be performed as early as possible, so that refreshing of all 4 pages can be done together.	The new version 2.04 of the Alice flight software was successfully uploaded into the remaining three EEPROM pages (the new version had been uploaded to the one other page earlier and tested). Memory checks and dumps were performed, which confirmed that the upload was performed correctly. (Reference: E-mail by Joel Parker of 31 Oct 2005.)	

OBS	Title	Objectives	Results	Ref.
MR01	Spectroscopy	• Changes in the coma composition induced by the impact. • Enhancement of water. The amount of water in the coma may indicate how much water ice is contained in the crater material. • Detection of carbon monoxide. • Doppler shift of -3.92 km/s is well within the passband of MIRO.	• We placed an upper limit on the water production rate in the pre-impact phase of the experiment, and measured the water production rate, albeit with low signal-to-noise, in the post impact phase. The water production rate was determined to be less than had been anticipated based on models. • No CO was detected, however the analysis is not complete at this time. • An estimate of the Doppler velocity was obtained. The objectives of the experiment were met. The results of this experiment were reported at the ROSETTA SWT 19 meeting on September 2, 2005. (Reference: E-mail by Sam Gulkis of 9 Sep 2005.)	RD16

3. Operations Reporting

All reported issues that impact payload operations, generated during the DI Observations scenario, are presented here. Reports from each PI team are listed, followed by reports from RMOC and RSOC. An overview of the open OOL / events and raised Anomaly Reports is given at the beginning of the RMOC section.

In particular, this chapter describes the problems encountered that do not show up as OOL / events or Anomaly Reports and that are not contained in the Mission Operations Report (AD5). However, details of the most important OOL / events and Anomaly Reports are repeated.

All issues are tracked in RD3 and RD4, giving the status of issues generated in this and all previous scenarios.

3.1 OSIRIS

3.1.1 Simultaneous commanding anomaly

Reference: E-mail by Michael Küppers of 14 Sep 2005, ROS-SC-93.

Description: The "simultaneous commanding" anomaly which caused interruption of OSIRIS observations on June 29 is described in anomaly report ROS-SC-93. Acquire Image / Dark sequences for NAC and WAC were scheduled for execution at the same time approximately every 6 hrs over the entire DI timeline.

Actions: RMOC manually deleted the conflicting sequences from the timeline for POR1. The OSIRIS team re-delivered a corrected POR2.

Conclusions: In the short term this constitutes a new constraint to be checked by EPS. In the long term the OSIRIS instrument software will be corrected (Active PC4). In general scheduling of several sequences for execution at the same time should be avoided in the future.

3.1.2 CCD shutter errors type D

Reference: E-mail by Michael Küppers of 14 Sep 2005.

Description: There were 4 CCD shutter errors type D which are covered by ROS-SC-57 from OSIRIS commissioning.

Actions: None.

Conclusions: Investigation of the anomaly by the OSIRIS team is ongoing.

3.1.3 CCD shutter errors type A (locking error)

Reference: E-mail by Michael Küppers of 14 Sep 2005.

Description: There were 2 CCD shutter errors type A (locking error). Those are known to occur occasionally when the instruments are run without shutter re-calibration for a long time or in unstable conditions. In both cases the instrument recovered automatically and the subsequent exposures were fine. For comparison, the total number of images was 2377.

Actions: None.

Conclusions: CCD shutter errors type A can be tolerated. No action required.

3.2 VIRTIS

3.2.1 CCD temperature too high OOL

Reference: E-mail by Fabrizio Capaccioni of 4 Jul 2005.

Description: The H/K data do not show any instrument malfunction. The CCD temperature increases steadily throughout the operations, due to the thermal dissipation, and reaches thermal equilibrium conditions at about 197 Kelvin almost at the end of the session (around 6 hours after the impact). This behaviour was expected as was observed already on ground during calibration, however, as the previous in-flight sessions were much shorter than the present one, we never reached these temperature levels and never thought of extending the range to include max variations.

Actions: The OOL of NVRA0033 M_CCD_TEMP was ignored after confirmation by the VIRTIS team that the instrument status was nominal.

Conclusions: The range of the OOL of NVRA0033 M_CCD_TEMP should be extended.

3.3 ALICE

Reference: E-mail by Joel Parker of 31 Oct 2005.

There were no anomalies or unresolved OOLs for Alice during the Deep Impact operations. All activities went as planned and were as expected by the Alice team based on the final plan accepted by us and RSOC before operations began.

3.4 MIRO

3.4.1 SSMM dump strategy

Reference: E-mails by Sam Gulkis and Lucas Kamp of 4 Jul 2005, AD5.

Description: On 04-Jul-2005, the day of the Deep Impact collision with comet Tempel 1, MIRO did not receive any post-impact data, which was required to decide on the sequence parameter update by 18:00 UTC on the next day. This was caused by the parallel dump of OSIRIS and VIRTIS large science packets. MIRO is generating short science packets and automatically gets less downlink bandwidth if given the same dump priority compared to other experiments with larger packet sizes.

Actions: Early on the following day it was decided to start the downlink of MIRO science before all the other dumps, such that the backlog could be recovered within a few hours.

Conclusions: The current SSMM dump OBCP does not provide flexibility. RMOC will modify the OBCP in order to allow selection of which packet store is dumped with what priority. RSOC will model the data volume generation and SSMM dumps, and specify the dump configuration per pass in the POR.

3.5 RMOC

3.5.1 RMOC Reported OOL / Events and Raised Anomaly Reports

All OOL and unexpected events encountered during the scenario are listed and tracked in RD4. Table 3 indicates the number of OOL and unexpected events that remain open. In addition, the table lists the Anomaly Reports raised and their status.

Table 3: OOL and events status.

Experiment	No. of open OOL	No. of open events	AR Ref.	AR Status
OSIRIS	–	–	ROS-SC-93	pending
VIRTIS	1	1	–	–
ALICE	–	–	–	–
MIRO	–	–	ROS-SC-96	pending
COSIMA	–	–	–	–
ROSINA	–	–	ROS-SC-95	pending
NAVCAM	–	–	ROS-SC-94	pending
NAVCAM			ROS-SC-97	closed
NAVCAM			ROS-522	closed

3.5.2 PI contacts during passes not always reliable

Reference: RRIM #16, RD12.

Description: PI team representatives could sometimes not immediately be reached during the passes although several phone numbers and persons were given in the contact list.

Actions: None.

Conclusions: It shall be emphasised to the PIs that the identified persons shall be available.

3.6 RSOC

There are no anomalies to report by RSOC.

4. Planning Feedback

Feedback on the planning process used for the scenario is presented here. Comments from each PI team are listed, followed by comments from RMOC and RSOC.

4.1 OSIRIS

4.1.1 General planning strategy

Reference: E-mail by Michael Küppers of 14 Sep 2005.

The planning process is becoming more efficient each time. It was a good decision to merge team inputs to one SPL issued by RSOC and iterate on that instead of individual SPLs by each team. Iteration on time lines was quick and smooth this time. Both RMOC and RSOC were very flexible when OSIRIS went back to operations and deleted some sequences.

4.1.2 RMOC involvement in the iteration of the pointing profile

Reference: E-mail by Michael Küppers of 14 Sep 2005.

RMOC should be involved in the pointing plan / SPL at an earlier stage to make planning more efficient. See sect. 4.6.1.

4.1.3 Short-term changes of command requests

Reference: E-mail by Michael Küppers of 14 Sep 2005.

We need to investigate how to improve the process of implementing short-term changes to a program (this is not really an issue for DI but for operations at the comet): For example, for OSIRIS it is possible to completely mess up a program with parameter changes only. At the same time, there are completely harmless possibilities for changes which insert / delete / replace telecommands. Also, I would expect the response time of several days for any changes to be too slow at the comet.

4.1.4 No commands allowed in ITL/POR (only sequences)

Reference: E-mail by Michael Küppers of 14 Sep 2005.

Occasionally the conversion of telecommands into sequences and back causes trouble (e.g. default parameter issue). Since there are many sequences containing only a single telecommand (at least for OSIRIS), it would be good to have a way to submit telecommands and avoid the conversion and re-conversion.

RSOC comment: We process telecommand sequences in the ITL/POR because this allows grouping of telecommands that are used in regular activities. Sequences can be validated, giving a first level of safety. It is understood that some commands remain independent so that a corresponding sequence containing the single command needs to be defined. However, we think that including both sequences and commands on the timeline would be confusing and reduce the safety of the planned spacecraft operations.

4.2 VIRTIS

No comments.

4.3 ALICE

4.3.1 Streamlining of planning strategy, EPS usage

Reference: E-mail by Joel Parker of 31 Oct 2005.

In general, we were happy with the final result of the planning process. However, it will certainly have to be further simplified and streamlined for the long-term operations around the comet. One move in that direction was the use of the REPEAT/SEPARATION parameters, which greatly simplified our ITL design and made the OIOR files easier to read. Getting EPS finally running here (with help from RSOC) was also very useful in being able to better check our files before submitting them.

4.4 MIRO

Reference: E-mail by Sam Gulkis of 9 Sep 2005.

The planning process went smoothly.

4.5 RMOC

4.5.1 Automated pointing planning interface

Reference: RRIM #16, RD12.

Currently the pointing plan is communicated via human-readable documents between RSOC, FDT and FCT. Then the FDT needs to manually input the pointing profile into the computer system that generates the AOCS commands and attitude file, which leads to a very high workload. The process is also very vulnerable to misunderstandings and errors. The complexity of the DI observations was at the limit of what can be handled in this manual way.

An automated pointing planning interface will be set up for future operations. A dedicated meeting with software experts will be organised that shall define the basis for this interface. Proposals were provided by the FDT and RSOC and shall be the starting point for the discussion.

4.5.2 Repetitive blocks of operations

Reference: RRIM #16, RD12.

Repetitive blocks with 3 hrs periodicity greatly simplified the planning and in particular allowed faster re-planning and re-joining of the original timeline in case of anomalies.

4.5.3 Maintenance slots

Reference: RRIM #16, RD12.

Identification of "maintenance slots" like the Wheel Offloading windows was very useful for resolution of anomalies without larger impacts on the original timeline. This was used for the recovery of the corruption in the transfer of OSIRIS science data over the High Speed Link to the SSMM.

4.5.4 Lead time for RMOC before uplink

Reference: RRIM #16, RD12.

The PORs were delivered 3 weeks before uplink start so that RMOC could perform all confidence checks and establish an uplink strategy. This is considered as necessary lead time for pre-comet scenarios. In the comet phase this will have to be shortened, but will be supported by more automated tools.

4.5.5 Delete PORs

Reference: RRIM #16, RD12.

The planning tools required for continuous intense science operations are not yet existing, and the available ones are still quite heavy to use. This is due to the fact that the start of science production is only foreseen in several years from now. In particular, no tools exist in support of contingency re-planning on the RSOC side, and all activities have to be carried out manually at RMOC.

At the beginning of the campaign, "delete PORs" would have greatly facilitated the recovery from the OSIRIS commanding problem (see sect. 3.1.1). RSOC will have the capability to produce "delete PORs" latest for the comet phase.

4.5.6 Grouping of PORs and FDRs into zip files

Reference: RRIM #16, RD12.

It is proposed to split PORs by experiment and deliver them together in a "PORG" group. This mechanism exists and is used by MEX, Smart-1 and VEX.

RMOC will discuss with Software Support and write an SCR in order to improve the way of importing sets of PORs and FDRs in the Scheduler.

4.5.7 Scheduler performance

Reference: RRIM #16, RD12.

In the short term no improvements to the software will be considered. Possible improvements could be achieved by using a faster machine (linked to the migration to Evolution). The use of the VEX MPS in the medium term is under consideration.

4.6 RSOC

4.6.1 RMOC involvement in the iteration of the pointing profile

Reference: RRIM #16, RD12.

RMOC was not involved in the iteration of the pointing profile in the beginning, and the finalisation meeting was too late. As a result, major changes had to be made on RSOC side to an already detailed plan.

In the future, the FCT will participate in all PI-RSOC telecons and involve Flight Dynamics if needed.

4.6.2 Time required for the iteration of the pointing profile

The iteration of pointing profile was very stressful for the RSOC team. Therefore 2 weeks are added in the generic schedule for events.

4.6.3 Resource files

Reference: RRIM #16, RD12.

The available power, data volume and MTL commands have been exchanged via e-mail.

RSOC requests that RMOC shall follow the SOIA interface definition and provide this information as the resource files for power, data rate and number of entries in the MTL. The power resource file contains the total power available for the scientific experiments as a function of time. The data rate resource file contains time windows of data rates. Only the data rate available for science data after housekeeping has reached real time shall be given. The MTL resource file contains the number of TCs for the entire payload for a period from LOS N to LOS N+1 (currently 1000 TCs).

RMOC investigates if the resource files can be provided already for the pre-comet science phases.

4.6.4 NAVCAM calibration images

Reference: RRIM #16, RD12.

NAVCAM images were stacked due to the weak signal from Tempel 1. The total exposure time of 10 min was still on the low side. Calibration images are required to reduce the noise by image processing. At the last RRIM it was decided to produce these calibration images during the next Active PC4 in Nov / Dec 2006.

5. Payload Resources Analysis

A comparison is made between

- Resource usage predicted by the PI teams during the planning process.
- Resource usage computed by EPS v1.9.1 using the EDF models as of 6 Oct 2005, i.e. SR v1.18, VR v1.25, AL v1.37 and MR v1.33. After the execution of the DI observations, the simulation of the SSMM packet stores and data downlink by the EPS was greatly enhanced and the EDF models for SR, AL and MR were improved. **Therefore the resources analysis given in this report was not possible during the planning process.**
- Real resource usage. Real power values were fetched from the SCOS-2000. Real data volume values were provided by RMOC (Frank Leake).

Analysis notes:

- Anomalies obviously change the real resource usage from the PI prediction and EPS simulation.
- Figure 1 in App. A shows the data generation and dump profile from the EPS simulation separated by experiments, assuming equal downlink priorities for all experiments. EPS was not capable of providing this when we were planning the DI observations, otherwise we would have spotted that MR is overwhelmed by SR and VR on 4/5 Jul (DOY 185/186).
- The analysis of the power profiles shows that fixed power values can be assigned to specific experiment modes. The quantitative comparison between PI prediction / EDF model / real power values is based on these modes.
- The real power values are fluctuating. The maximum real power values in the different experiment modes are used for the calculation of the accuracy of the PI predictions and EDF models.
- Any additional headers from ground (DDS and SFDU headers) are NOT included in the reported data volume values.
- Real data volume values are filtered on ground received times.

- EDF modelled and real data volume values are available for science only and not for housekeeping.
- Time step of the EPS simulation is 10 min. Time step of the real power values also is 10 min.
- Real data volume values are only available as totals per month for each experiment. In June before the DI observations, SR was operated to perform a software upload and test, but VR, AL and MR were off. In July, no other payload activities were carried out after DI. Therefore, for SR the comparison of PI prediction / EDF model / real data volume is based on the values of July only. VR was measuring on 4 Jul (DOY 185) only. For AL and MR the whole DI period is taken into account.
- The SR simultaneous commanding anomaly effected the real power and data volume values mainly from about 29 Jun (DOY 180) 04:15 to 30 Jun (DOY 181) 14:34. This is clearly visible in the real power profile. As described above, the data volume generated in June is not included in the comparison. As a recovery action, a few images were removed from the subsequence timeline. In addition, single images were lost due to other minor anomalies. The total effect on the real science data volume is negligible.
- MR suspended nominal operations from 8 Jul (DOY 189) 09:59 to 9 Jul (DOY 190) 05:49. On 14 Jul (DOY 195) after the end of the DI observations, MIRO was power cycled and operated for about 2 hrs. This is clearly visible in the real power profile. The nominal real science data volume is estimated to be reduced by about 20 MBytes (i.e. the daily data volume predicted by the PI).
- The AL memory patch (AL05) was performed interactively by RMOC during the pass on 14 Jul (DOY 195), so there is no corresponding OIOR and the power and data volume are not included in the EPS simulation. AL05 did not generate any science data, the only products were memory checksums and memory dumps.
- Legend: After resource usage predicted by PI team or computed by EPS (columns 3 & 4), ↑ means that value is greater then real resource usage, ↓ means that value is less than real, ↔ means that value is equal to real, ? means unknown. Percentage of inaccuracy is also given. The value that is closer to the real resource usage is formatted in bold.
- In the current mission phase, estimated values within a margin of 20% of real values are considered sufficient.

Table 4: Payload resources data: Estimated vs. real values.

Experiment	Resource	PI Estimate	EPS Estimate	Real	Comments
AL	**HK (MBytes)**	Jun & Jul, AL01-04: 3.11 MBytes			• AL05 did not generate any science data (which would be included in the Real SCI otherwise). • See Figure 1 in App. A for data generation and dump profile from EPS simulation. • See Figure 2 in App. B for AL power profile, EPS simulation and real values superimposed.
	SCI (MBytes)	Jun & Jul, AL01-04: **78.65 MBytes** **↓ 3%**	Jun & Jul, AL01-04: 77.91 MBytes ↓ 4%	Jun & Jul, AL01-04: 80.74 MBytes	
	PWR (W)	Histogram acquisition only: **4 W** **↓ 5%**	Histogram acquisition only: 3.3 W ↓ 21% Histogram acquisition & optics heaters: 5.3 W ↓ 17%	Histogram acquisition only: 3.1 … 4.2 W Histogram acquisition & optics heaters: 5.3 … 6.4 W	
MR	**HK (MBytes)**	Jun & Jul, MR01: 1.73 MBytes			• The MR anomaly is assumed to

Experiment	Resource	PI Estimate	EPS Estimate	Real	Comments
	SCI (MBytes)	Jun & Jul, MR01: 327.3 MBytes ↑ 1%	Jun & Jul, MR01: **325.52 MBytes** **↑ 1%**	Jun & Jul, MR01, reduced by anomaly: 303.57 MBytes Jun & Jul, MR01, corrected for anomaly: 323.57 MBytes	reduce the nominal Real SCI by 20 MBytes. For the comparison with the PI & EPS Estimate SCI, the Real SCI is corrected accordingly. • See Figure 1 in App. A for data generation and dump profile from EPS simulation. • See Figure 3 in App. B for MR power profile, EPS simulation and real values superimposed.
	PWR (W)	70 W ↓ 3%	**70.76 W** **↓ 2%**	64 … 72 W	
SR	**HK (MBytes)**	Negligible			• The SR anomaly mainly effects the Real SCI for DI in June which is not available anyway. • The effect on the Real SCI in July of the few lost images is negligible.
	SCI (MBytes)	Jun & Jul, SR01: 382.02 MBytes Jul only, SR01: 338 MBytes ↑ 21%	Jun & Jul, SR01: 333.4 MBytes Jul only, SR01: **289 MBytes** **↑ 3%**	Jul only, SR01: 279.40 MBytes	

Experiment	Resource	PI Estimate	EPS Estimate	Real	Comments
	PWR (W)	Imaging: 50 W ↓ 4%	Imaging: **50.2 W** **↓ 3%** Setup: 25 W ↓ 26%	Imaging: 25 … 52 W Setup: 11 … 34 W	• The PI team estimated the SCI far too high because they used a method with a low accuracy and rounded the data volume up for safety. • See Figure 1 in App. A for data generation and dump profile from EPS simulation. • See Figure 4 in App. B for SR power profile, EPS simulation and real values superimposed.
VR	**HK (MBytes)**	4 Jul, VR01: < 1 MByte			• See Figure 1 in App. A for data generation and dump profile from EPS simulation. • See Figure 5 in App. B for VR power profile, EPS simulation and real values superimposed.
	SCI (MBytes)	4 Jul, VR01: 46.025 MBytes ↑ 16%	4 Jul, VR01: **42.4 MBytes** **↑ 7%**	4 Jul, VR01: 39.52 MBytes	
	PWR (W)	Science: **39 W** **↑ 18%** Idle: 32 W	9.9 W ↓ 70%	24 … 33 W	
SE	**HK (MBytes)**	Included in SCI.			SE is operating in the background. No OIOR.
	SCI (MBytes)	Jun & Jul, DI: 2.7 MBytes		SE is operating continuously before and after DI, so Jun and Jul totals cannot be used in comparison.	

Experiment	Resource	PI Estimate	EPS Estimate	Real	Comments
	PWR (W)	Covered outside given resource.			
Totals	**HK (MBytes)**	Jun & Jul, DI: 5.84 MBytes			• The total power values are the sum of the maximum values for each experiment.
	SCI (MBytes)	Jun & Jul, DI: 836.695 MBytes	**Without SE,** Jun & Jul, DI: 779.23 MBytes	Real SCI unknown for SR in Jun, DI.	
	PWR (W)	**163 W** ↔	136.16 W ↓ 17%	163.4 W	

Table 5: Summary of payload resources analysis.

Experiment	Data Volume	Power Consumption
Real values	For a detailed comparison of the real science data volume profile with the PI prediction and EPS simulation, the amount of data downlinked during each pass and for each experiment is needed. However, RMOC only delivered totals per month and experiment which also included data generated by SR during other operations performed before DI.	The real power values are fluctuating. The maximum real power values in the different experiment modes are used for the calculation of the accuracy of the PI predictions and EDF models.
Anomalies	Anomalies obviously change the real data volume from the PI prediction and EPS simulation. The SR anomaly occurred in June when the SR real science data volume for DI is not available anyway. The effect on the real science data volume of the few lost images in July is negligible. For MR, an estimate was made in order to correct the real science data volume for the MR anomaly.	The anomalies can be clearly distinguished in the real power profiles for SR and MR.
AL05	The AL memory patch (AL05) was performed interactively by RMOC, so there is no corresponding OIOR to be used in the EPS simulation. The science data volume produced by AL05 is unknown. AL05 is included in the real science data volume, but missing in the value computed by the EPS.	The execution of the AL memory patch (AL05) can be clearly distinguished in the real power profile for AL.

Experiment	Data Volume	Power Consumption
Downlink	Figure 1 in App. A shows the data generation and dump profile from the EPS simulation separated by experiments, assuming equal downlink priorities for all experiments. MR is overwhelmed by SR and VR on 4/5 Jul (DOY 185/186). Afterwards 3 passes are needed to recover the backlog. This problem was not spotted during the planning process because EPS was not capable of properly simulating the data downlink at that time. In reality, on 5 Jul the downlink of MR science was started before all the other dumps and the backlog could be recovered within a few hours. Although EPS can presently model different downlink priorities for the experiments, at the moment the dump configuration cannot be changed during the scenario.	
PI prediction general	AL and MR predicted their science data volumes to within 5% margin. SR and VR overestimated their science data volumes by 21% and 16%, respectively. The SR team explained that they used a method with a low accuracy and rounded the data volume up to be on the safe side..	AL, MR and SR predicted their power during normal measurements to within 5% margin. However, AL did not state the additional power required by the optics heaters. VR overestimated their power by 18%.
EPS simulation general	The EPS simulation overestimates the real science data volume for MR, SR and VR, only AL is underestimated. AL, MR and SR are even accurate to within 5% margin. For VR the error is 7%.	The EPS simulation always underestimates the real power. For AL, MR and SR the discrepancies are caused because the real power is fluctuating. The EDF model for VR is severely wrong.
AL	EDF accurate to within 20% margin.	EDF marginally inaccurate to within 20% margin. Absolute power consumption is low.
MR	EDF accurate to within 20% margin.	EDF accurate to within 20% margin.

Experiment	Data Volume	Power Consumption
SR	EDF accurate to within 20% margin.	EDF inaccurate to within 20% margin. The inaccuracy only occurs during setup phase.
VR	EDF accurate to within 20% margin.	EDF inaccurate to within 20% margin.

6. Action Items for RSOC

AI-DI-1 RSOC and FDT shall set up an automated pointing planning interface. See action RR16-13 (RD12).

AI-DI-2 RSOC shall discuss the PORG for Rosetta and produce an SPR to EPS.

AI-DI-3 RSOC shall set up the capability to produce "delete PORs".

AI-DI-4 RSOC shall improve the modelling of the data volume generation and SSMM dumps. After RMOC has modified the SSMM dump OBCP to allow specification of the dump configuration per pass, RSOC shall incorporate this into the EPS.

AI-DI-5 RSOC shall discuss the process of implementing short-term changes to an ITL/POR.

7. Conclusions

The science objectives of the Deep Impact Observations scenario were met. The brightness increase of Tempel 1 produced by the impact was lower than we had hoped for, and as a result the comet was too weak to be detected by VIRTIS. For ALICE and MIRO the signal was just above the sensitivity limit, but nevertheless important measurements could be achieved. The results of OSIRIS even exceeded the expectations, and the first scientific publications are widely cited. The data collected by the experiments on board Rosetta are unique because Tempel 1 was monitored continuously over an extended period of time (no day-and-night cycle in contrast to ground-based telescopes) and in the absence of an absorbing atmosphere. The scientific processing and evaluation of these data is still in progress, but it has already provided indications of the high quality of the data and possible results.

From an operational point of view, the observations were executed almost perfectly. Minor problems concerned simultaneous commands for OSIRIS and suspension of MIRO operations for 20 hrs. Both anomalies could be recovered within about 24 hrs, with only very little impact on the overall instrument operations and data return.

Although the planning process mostly went smoothly, important lessons have been learned for both pre-comet scenarios and the science operations at 67P/Churyumov-Gerasimenko. Repetitive blocks of operations and maintenance slots greatly simplified the planning and resolution of anomalies. RMOC shall be involved in the iteration of the pointing profile earlier.

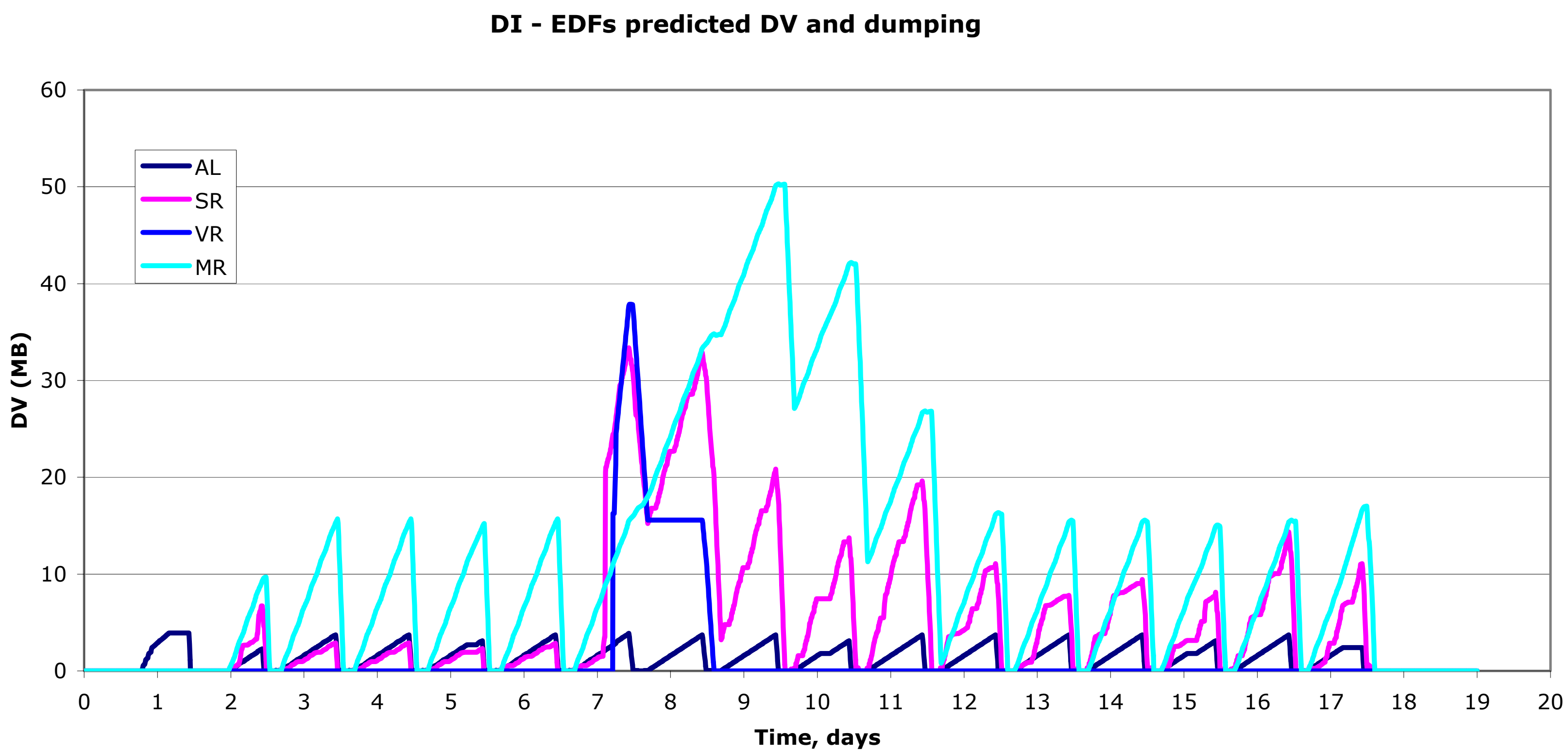
The planning tools required for continuous intense science operations are not yet existing because the start of science production is only foreseen several years from now. Going through the planning process with the available tools involved a lot of manual activities and a heavy workload for all participating teams. The most urgent improvement is an automated pointing planning interface that shall be operational for the Active PC4.

The resource usage was simulated with the EPS and EDF models available on 6 Oct 2005 and compared with the real values. The modelling of the science data volume generation for OSIRIS, VIRTIS, ALICE and MIRO and the data downlink are very accurate. The modelling of the power consumption is very good for MIRO. The power model for ALICE and OSIRIS needs minor adjustments to account for the power fluctuations and setup phases. The power model for VIRTIS requires major updates. Note that the resources analysis given in this report was not possible during the planning process, as the EPS and EDF models were greatly improved in the meantime.

In summary, the Deep Impact Observations scenario was planned and executed very successfully. It was the first important active science phase for the Rosetta mission and constituted a major operational test involving complex and long-duration science operations. Valuable experience was gained that will be used to design the planning concept and operations in the comet phase. The performance of the ground segment, the spacecraft and the experiments was excellent. The outstanding contribution and dedication of the PI teams, FCT, FDT and RSOC is acknowledged and highly appreciated.

8. Appendix A: Data Volume Profile

Figure 1: EPS simulation of the science data volume in the experiment packet stores vs. time. The time is counted from 27-Jun-05 (DOY 178) 00:00:00.



9. Appendix B: Power Profiles

Figure 2: ALICE power vs. time, EPS simulation and real values superimposed. The time is counted from 27-Jun-05 (DOY 178) 00:00:00. The AL memory patch (AL05) was performed interactively by RMOC during the pass on 14 Jul (DOY 195), and the corresponding power is not included in the EPS simulation.

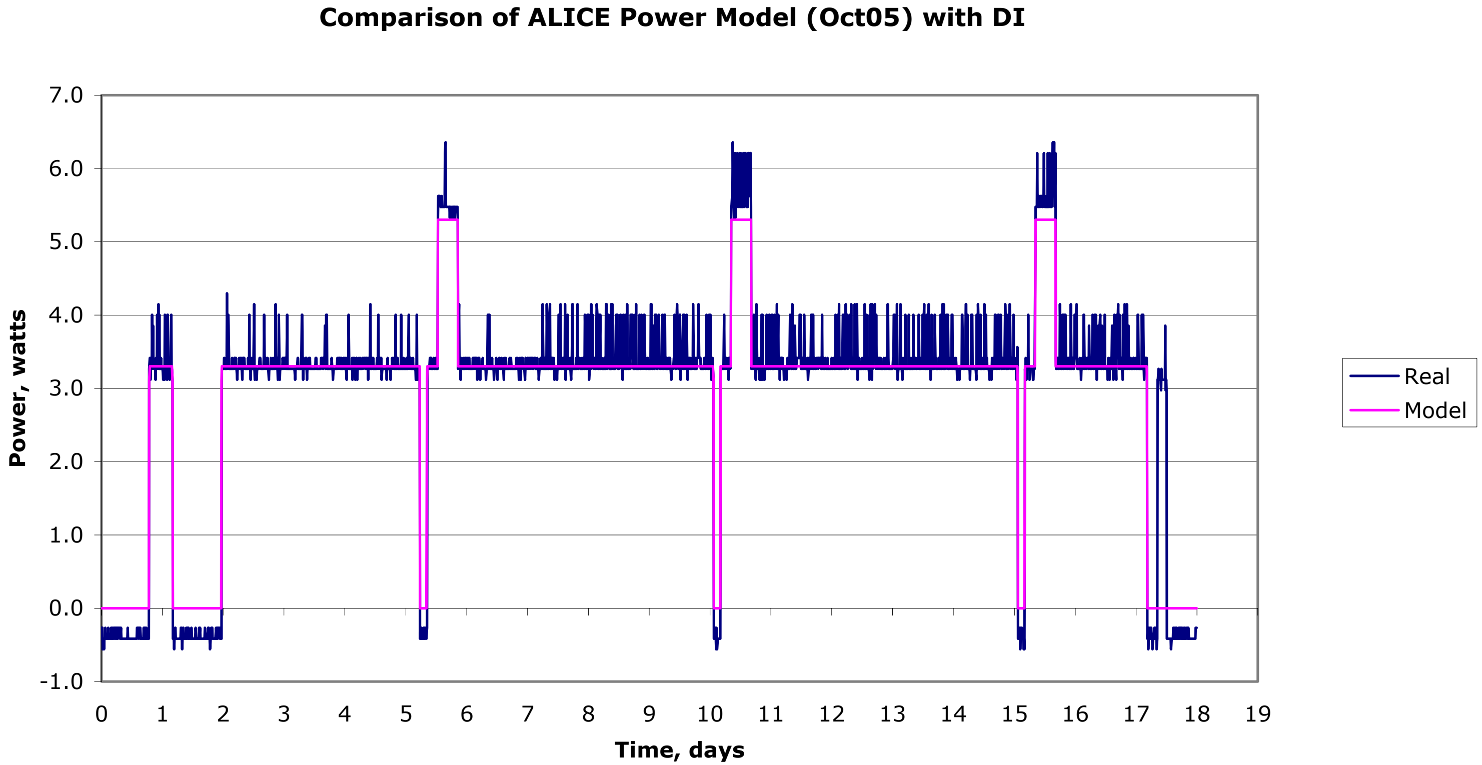


Figure 3: MIRO power vs. time, EPS simulation and real values superimposed. The time is counted from 27-Jun-05 (DOY 178) 00:00:00. The discrepancies on 8/9 Jul (DOY 189/190) are caused by MIRO suspending nominal operations for about 20 hrs. On 14 Jul (DOY 195) after the end of the DI observations, MIRO was power cycled and operated for about 2 hrs.

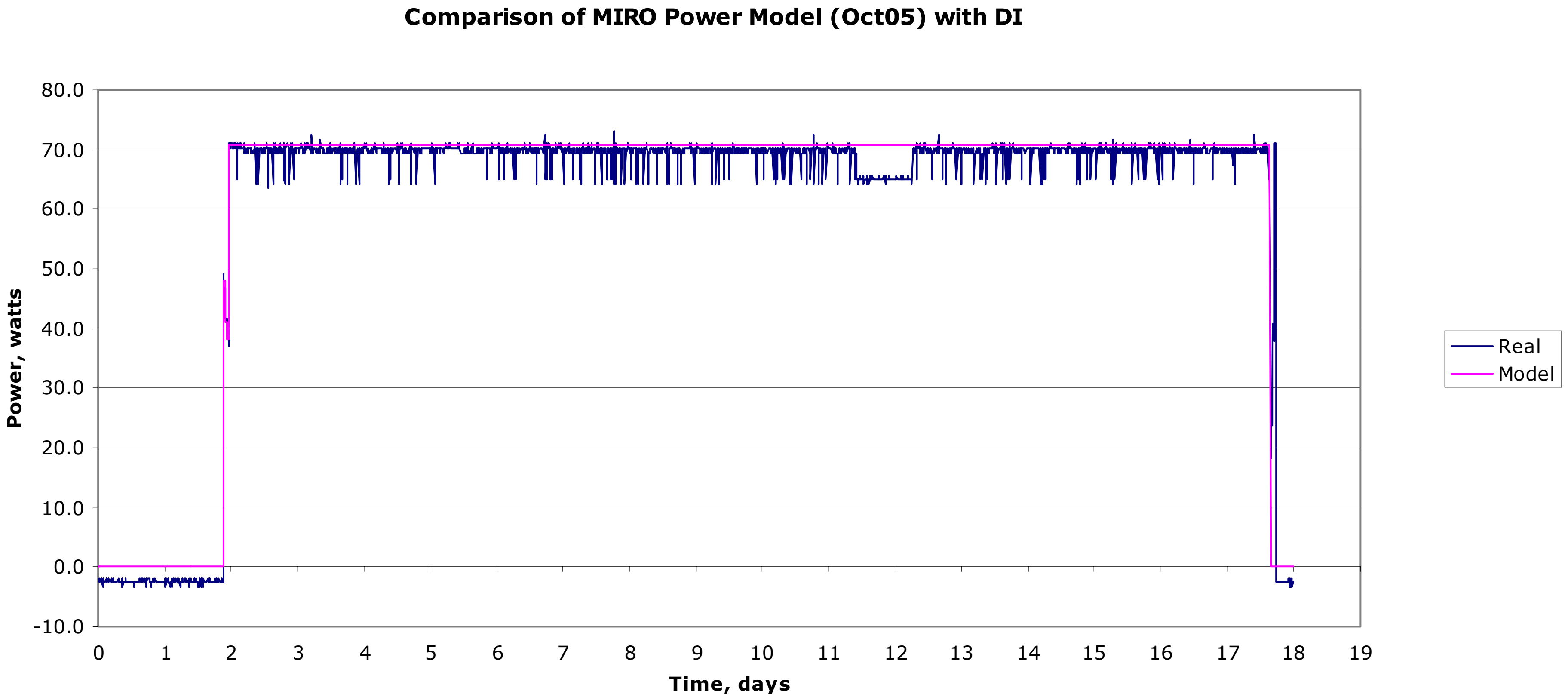


Figure 4: OSIRIS power vs. time, EPS simulation and real values superimposed. The time is counted from 27-Jun-05 (DOY 178) 00:00:00. The discrepancies on 28/29 Jun (DOY 180/181) are caused by the simultaneous commanding anomaly.

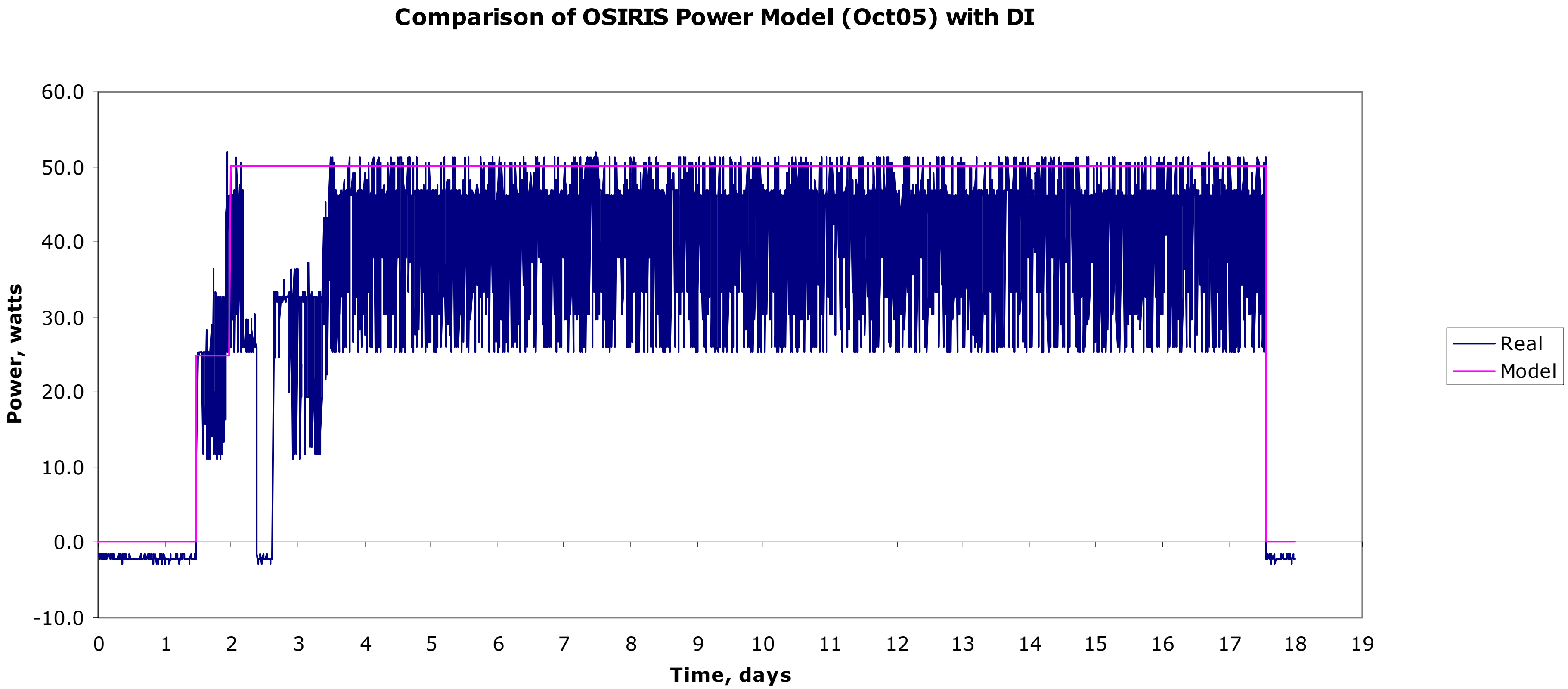


Figure 5: VIRTIS power vs. time, EPS simulation and real values superimposed. The time is counted from 27-Jun-05 (DOY 178) 00:00:00.